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Cables :: "Stomata." | Phone :: 2183

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THE LIME OIL INDUSTRY.

THE unsatisfactory situation which has arisen in the distilled lime oil market during the past eighteen months has caused considerable uneasiness amongst producers. With lime oil values falling rapidly it became expedient to find some means of checking the downward trend of prices which, according to the trade, would appear to have been due not so much to a diminished demand by consumers as to unnecessary competition between sellers, bringing in its train certain obvious disadvantages. Producers have felt that this state of affairs could not continue without seriously influencing prices and they have recently decided to rationalise the marketing of their product.

The West Indian Colonies chiefly interested in distilled lime oil are Trinidad, St. Lucia and Dominica. Grenada and British Guiana also are exporters but their production does not compare with that of Trinidad and St. Lucia which has risen very appreciably during the past few years. Trinidad is at present the largest producer and it was in this Colony that the first move was made towards creating a co-operative organisation among lime growers to market their oil. This organisation, actually formed early this year, resolved to market all the oil of the island through a single firm of brokers in the United Kingdom. By this means it was felt that better prices might be obtained since the broker would have a virtual control over all the oil produced in the island. The Trinidad growers next approached the St. Lucia producers with a view to asking their support in the scheme. The St. Lucia interests were, however, not able to agree as they were of the opinion that a firm of brokers would find it extremely difficult to allocate sales equitably between producers. In view of this objection, an alternative scheme was drawn up in consultation with Trinidad involving the formation in each Colony of local associations to be known as the Lime Oil Producers of Trinidad and the Lime Oil Producers of St. Lucia. These associations will in turn be members of a Central Association with headquarters in Trinidad to be called the West Indian Lime Oil Sales Company, Ltd. Briefly the local associations will be responsible for allotments and for distributing the proceeds of sales to their members and for the general welfare of the lime oil industry in each Colony. The Central Association's main objects will

cnlude the marketing of lime oil and the safeguarding of the interests of its members. All the oil produced in the two Colonies will also be placed at its disposal for sale and it will make allocations between the members on a production basis. The constitutions of the three associations have been drawn up and they have recently been registered as limited companies. A well known firm in Trinidad has been appointed as their sales agent and all contracts will in future be made by the West Indian Lime Oil Sales Company Ltd. through this agency. It is understood that Dominica, British Guiana and Grenada have also been approached in regard to the scheme.

There is no doubt that the success of these associations will depend mainly on the loyalty of their members, especially during difficult times and in the face of any opposition that may arise. Careful attention will have to be paid to the question of the supply and demand of the article. As long as these are almost equal the scheme should work quite smoothly but difficulties might arise if production were to increase unduly and stocks to accumulate. At the present time, owing to the concerted action which has been taken by the producers, the market for distilled lime oil appears to be quite firm and stocks are by no means excessive. There has, it is true, been a disappointing demand recently for the article but this has mainly been due to unseasonable weather conditions both in America and in England. The growth of the lime oil industries in other parts of the world will also have to be watched. It should be understood that it is not the aim of the associations to force unreasonable prices for the commodity. Planters, on the other hand, will benefit in that they will be assured, for a time at least, of fair values for their limes, a state of affairs for which credit will in a large measure be due to those responsible for promoting a system of organised marketing.

In view of the difficulties which may eventually occur in the lime oil market the launching of associations to protect West Indian interests seems quite opportune. The Central Association represents yet another step forward to secure co-operation between West Indian Colonies in the disposal of an important agricultural product and it is hoped that all islands interested will eventually join to secure such advantages as may accrue from co-operative marketing.

G. G.

DRIED GRAPEFRUIT REFUSE.*

THE use of dried citrus fruit by-products for livestock feeding has recently been investigated at the Florida Agricultural Experiment Station at Gainesville where it has been shown that dried grapefruit refuse can be successfully fed to cattle. The product which is prepared by a special drying process is derived from the peel, rag and seed of the fruit. In its final stage it consists of flakes and shreds somewhat coarser than beet pulp. In colour dried grapefruit refuse varies from a golden brown to a bright gold. It is characterised from other common stock feeds by a high content of citric acid, pectin and soluble sugars and by the presence of glucosides, pigments and essential oils. Its composition is: 91.77 per cent. dry matter, 4.94 per cent. crude protein, 11.94 per cent. crude fibre, 69.60 per cent. nitrogen-free extract, 1.06 per cent. crude fat and 4.23 per cent. ash. In view of its low fibre content and high percentage of nitrogen-free extract, dried grapefruit is regarded as a high carbohydrate concentrate.

The palatability of dried grapefruit refuse was tested in the dairy herd of the Florida Agricultural Experiment Station by offering one pound of the product to the individual cows of the dairy herd after they had eaten the normal quantities of maize silage and mixed grain. Of the 31 cows only one refused to eat the refuse while their appetites for it increased progressively during a six-day trial.

In the digestion trials which were conducted with four steers the grapefruit refuse was fed with cottonseed meal and alfalfa hay. These trials were continued for 30 days, 10 of which were preliminary and 20 experimental. Analyses revealed that approximately 25 per cent. of the protein, 71 per cent. of the fibre, 92 per cent. of the nitrogen-free extract and 80 per cent. of the ether extract had been digested by the steers. It was shown also that the product contained 1.23 per cent. digestible crude protein and a total of 76 per cent. digestible nutrients.

The general feeding qualities and effect of dried grapefruit were tested on eight heifers in a feeding trial that lasted 120 days. The daily ration used consisted of 30 lb. of sugar cane silage replaced at the end of 80 days by sorghum silage, 15 lb. of dried grapefruit refuse and 5 lb. of cottonseed per 1,000 lb. liveweight. This ration was very palatable. Although grapefruit refuse has a laxative action its general effects on animals were favourable as indicated by thrifty appearance, the gloss of the coat of hair and the improvement in thickness of flesh.

The experiments which have been conducted so far tend to show that when the drying processes have been perfected grapefruit refuse may become a profitable by-product instead of a source of waste in a cannery. Further studies on its physiological effects on the animal are still needed, however, as little at present is known on that subject.

G. G.

*The Feeding Value and Nutritive Properties of Citrus By-products. By W. M. Neal, R. B. Becker and P. T. Dix Arnold. Bulletin No. 275 of the Agricultural Experiment Station, University of Florida, Gainesville, Florida.

COTYLEDON COLOUR IN KOLA.

By O. J. Voelcker, M.A., A.I.C.T.A.,
(*Department of Agriculture, Nigeria*).

Of the numerous species of kola — *Cola* Schott & Endl—indigenous to West Africa, *C. nitida* A. Chev. is the most important commercially. Plantations of this species occur in the mixed deciduous or rain forest belts from Sierra Leone to the Cameroons, and up to the time of economic depression in 1929 its cultivation was spreading rapidly in Nigeria. The Yoruba peoples of the South Western Provinces produce the bulk of the crop which is sent to the kola chewing tribes of the North. The Yorubas themselves consume nuts of a different species—*C. acuminata* Schott & Endl—and the trade in these is distinct from that in *C. nitida*. Some indication of the importance of the *C. nitida* crop may be gathered from the fact that over 17,000 tons of nuts were carried north by the western line of the Nigerian Railway during 1934. The price varies with the size, keeping quality and colour of the nuts, and certain districts have made a name for themselves by excelling in one or other of these characteristics. Thus, within Nigeria, the Owode and Labozhi crops contain a high proportion of the more valuable pink nuts, while on the West Coast as a whole, Sierra Leone kola maintains the highest price partly on account of good keeping qualities. This paper is concerned with the variation in nut colour which so largely determines the value of of kola.

Description of *C. nitida*.

Very little literature has been published on kola, but full descriptions have been given by Chevalier and Perrot (1) and by Gregorio Bondar (2) and more recently by von Bernegg (3). For those unable to refer to these works it may be useful to give a few brief notes on the habit of this plant. *C. nitida* is one of the smaller ever-green forest trees reaching a height of 60 feet or more with branches spreading 20 feet from the trunk. The dark green leathery leaves, somewhat similar in shape to those of *Theobroma Cacao*, are borne on long petioles and give a dense shade. Flowering takes place sporadically throughout the year unless drought occurs. A main flowering flush commences in the middle of the Nigerian wet season (July-August) and gives rise to the crop which is harvested some four or five months later.

The flowers, which have a faint characteristic smell, are borne in racemes in the axils of leaves or leaf scars towards the distal ends of small branches and may be male, female or hermaphrodite. In general the flowers at the base of the raceme are male, those at the tip which can be noted by their rather larger size, female; hermaphrodite flowers are rare. There is, however, great variation in the porportion of male and female flowers between raceme and raceme and from tree to tree. Typically, the female flower has a five lobed calyx, five curved fleshy stigmas lying over the ovaries which in turn rest on a plate-like structure round the edges of which are two rows of ten rudimentary stamens. The number of carpels may vary from one to six. In the male flowers the anthers develop fully and yield a yellowish slightly sticky pollen; the gynoecium is absent.

The fruit is in the form of green wrinkled ellipsoid follicles, of which there are generally five, arranged as a star and suspended from the centre by a long woody fruit stalk. Each follicle contains one to ten nuts which are surrounded by a white cartilaginous skin. The nut of *C. nitida* is homologous to the cacao bean in that it is composed of two cotyledons. The convolutions within the cotyledons are, however, absent in kola. Kola nuts are handled in trade, or stored, after the cartilaginous skin has been removed so that the visible characteristics of the nuts are those of the cotyledons.

Incidence of Colour in Kola Nuts.

Kola nuts vary in colour from dark red to pure white. The dark red are the most common, the varying shades of pink less so and the white comparatively rare. The value of the nuts increases as the white or lighter pink shades are approached. Whether this is due to a scarcity of the lighter coloured nuts or to possible superiority in flavour it is difficult to say. At all events, pink and white nuts are eagerly sought by those who buy the crop and command a higher price than red nuts.

Not only may nuts of different colour be found on the same tree but also within the same fruit follicle. Moreover, the proportion of nuts of different colours may vary on the same tree from year to year. It is well known among kola farmers that, if they plant pink nuts next to red, initially the trees grown from pink nuts will yield a high proportion of pink nuts, while after several years there will be an increasing number of red. This they explain by suggesting that the transference of colour takes place through the intermingling roots. A. Chevalier (*loc cit.*) tentatively divided *C. nitida* into the following sub-species:—*C. rubra*, trees producing only red nuts; *C. alba* producing only white; *C. nixta* producing red, pink and white, and *C. pallida*, trees producing small pale pink, or white and pink nuts mixed. The fact that the colour of nuts may alter from year to year on any one tree vitiates this classification. Chamney (4) working in the Gold Coast gives figures showing the variation of nut colour from year to year, and concludes that colour is a function of age and not a Mendelian character. The incidence of different colour in the two cotyledons of one nut is known, but the writer has not yet seen an example of this.

Kola Plots at Ibadan.

An investigation into the incidence of cotyledon colour was made possible at Ibadan by the fact that three plots of kola grown from different coloured nuts were fruiting. Plot Y5, 2.5 acres, was planted in 1913 with red nuts. Plot AW, .25 acre was planted in 1917 with white nuts, and Plot AE, also .25 acre, was planted at the same time with pink nuts. Plots AW and AE are distant from one another by 300 feet, and the Y5 plot distant from both by nearly half a mile. No other specimens of *C. nitida* are growing anywhere near. Individual tree records were commenced in 1931 on the pink and white plots. These records included the colour of the nuts harvested. Considerable difficulty was found in classifying colour, and it was found by experience advisable to make only three classes; Red, Pink and White. Of these only the white can be said to be of one colour. Border line cases between red and pink occurred, and even red itself shewed different intensities. The colour of the nuts from the Y5 plots was not recorded, but with very few exceptions the nuts harvested were red.

The following table gives the number and colour of nuts produced by natural pollination from 1931 to 1934 for the AW and AE plots:—

Table I.—Natural Pollination.

	Number of Nuts Harvested.		
	White.	Pink.	Red.
AW. Planted with White nuts	1113	84	180
AE. Planted with Pink nuts	155	4427	332

Controlled Pollination.

In 1933 the technique of controlled pollination was investigated. Racemes, the flowers in which were about to open, were covered with grease-proof paper bags. As mentioned previously each raceme bears both male and female flowers; this facilitates controlled self pollination, since fresh pollen—detached on the sharpened end of a match—is available when the female flower opens. A high percentage of setting was obtained. Work during that year was confined to the self pollination of a number of trees in the AW plot, and these pollinations were continued during 1934. It may be interesting here to record that the self incompatibility noted by Pound (5) in Trinidad cacao was also observed on three of these kola trees. The number and colour of nuts harvested from self fertilized flowers were:—

Table II.—Self Pollination.

	Number of Nuts Harvested.		
	White.	Pink.	Red.
AW. Planted with White nuts	745	—	—

During 1934 a number of flowers from the AW plot was fertilized with pollen from the red kola in Y5 with the following results:—

Table III.—Cross Pollination.

	Number of Nuts Harvested.		
	White.	Pink.	Red.
AW Planted with White nuts crossed by pollen from Y5 planted with Red nuts	11	94	721

Reciprocal crosses were also carried out using pollen from trees in AW to fertilize flowers in Y5. The nuts harvested were as follows:—

Table IV.—Cross Pollination.

	Number of Nuts Harvested.		
	White.	Pink.	Red.
Y5 Planted with Red nuts crossed by pollen from AW planted with White nuts ..	—	60	149

Material in AE (planted with pink nuts) has not yet been used in controlled pollination.

Tables II, III and IV give the sum of nuts harvested from all trees which received similar pollination. It is now of interest to investigate the behaviour of individual trees. Unfortunately much of the cross pollination was commenced late in the year, and consequently flowers on several trees were scarce. Thus reciprocal crosses were not always possible.

Table V is presented to show the behaviour of pollen from individual trees growing in the Y5 plot when used to fertilize flowers in the AW (white) plot.

Table V.—"Red Tree" pollen on Flowers of "White Trees".

Y5 Plot.	AW Plot.	Number of Nuts Harvested.		
Pollen from Tree No.	Female flowers from Tree No.	White.	Pink.	Red.
11	10	—	—	40
59	13	—	—	17
69	44	—	—	97
113	19	—	—	54
121	14	—	—	54

Table V.—*Contd.*

Y5 Plot.	AW Plot.	Number of Nuts Harvested.		
Pollen from Tree No.	Female flowers from Tree No.	White.	Pink.	Red.
30	10	—	22	19
2	14	—	4	28
2	25	—	—	71
12	10	—	14	8
12	14	1	18	34
12	25	—	31	75
115	14	—	5	16
115	18	10	—	6
16	8	—	—	6
16	30	—	—	29
16	38	—	—	31
37	10	—	—	18
37	19	—	—	73
37	35	—	—	45

The flowers from the AW Trees Nos. 8, 10, 13, 14, 18, 19, 25, 35 when self fertilized gave white nuts only. No self fertilization was attempted on AW Trees Nos. 38 and 44, and No. 30 was found to be self incompatible.

A few pollinations were carried out on flowers in the red Y5 plot using pollen from trees in the white AW plot. Table VI shows the number and colour of nuts resulting from these crosses for each tree.

Table VI.

"White tree" pollen on "Red tree" Flowers.

Y5 Plot.	AW Plot.	Number of Nuts Harvested.		
Female flowers from Tree No.	Pollen from Tree No.	White.	Pink.	Red.
12	10	—	12	10
12	18	—	5	17
12	35	—	35	63
16	20	—	8	12
59	11	—	—	37
114	47	—	—	10

None of the flowers from these trees in the Y5 plot was self fertilized.

Discussion of Results.

The preceding data show that the colour of nuts in *C. nitida* varies within limits according to the parentage of the tree producing female flowers and of the tree which supplies the pollen. The nuts, being themselves cotyledons, thus depict the colour character of the succeeding generation. In a paper on the genetics of cotyledon colour in cacao by S. J. Wellensiek (6) of which the writer was unaware till 1933, the subject has been very fully studied. Unfortunately the colour classes used by the writer for kola differ from those of Wellensiek who designated very pale cacao beans as colourless when presenting ratios of coloured to colourless.

The fact that in kola only pure white nuts result from the self fertilization of flowers on trees grown from white seed suggests that this absence of colour is a recessive character. The incidence of colour is thought to be complex and would be attributed to several genes, the number of which determine the colour density. These hypotheses agree with Wellensiek's conclusions, and are borne out by A. S. and A. O. Bolt (7) also working on cacao.

Turning now to tables V and VI, if it were assumed that white is recessive and that the trees in the Y5 plot were pure dominant red, the expectation is that crosses either way should produce nothing but red nuts. In fact, pollen used from seven trees in Y5 to fertilize flowers in AW did so, but pollen from two trees (Nos. 30 and 2) yielded a mixture of red and pink and from two other trees (Nos 12 and 115) red, pink and white. Similarly two trees in Y5 (Nos. 59 and 114) when crossed with pollen from "white trees" in AW gave only red nuts, but two others (Nos. 12 and 16) gave red and pink. The suggestion put forward is that certain trees in Y5 were planted with red nuts which were not pure to the dominant colour character. Thus tree 12 in Y5 either when crossed with pollen from "white trees" or when reciprocally crossed yielded in every instance a mixture of pink and red.

Tree 59 could, however, be regarded as a true dominant red, since only red nuts result from it when used as male or female parent to "white trees". One example cannot at the moment be explained. Tree 16 in Y5 when crossed with "white pollen" gave pink and red nuts, but when used as the male parent yielded only red. Moreover the ratio of white to pink nuts, when trees Nos. 12 and 115 were used as male parents, and of pink to red with tree No. 2 is obscured.

It is realized that this paper leaves many gaps in the story of cotyledon colour and must be regarded only as a preliminary study. Nevertheless, certain data obtained from this investigation can be of great practical importance. To obtain pure white nuts a farmer must plant only white seed and arrange that his neighbours do not plant red seed close to his farm. The distance of out-pollination is uncertain but is not less than 300 feet, as is shown by the occurrence of pink and red nuts from naturally fertilized flowers in the AW plot.

Taken in conjunction with Wellensiek's work, this paper strengthens his recommendations for the improvement in quality of cacao by planting only white beans.

Summary.

1. The colour of the cotyledons of *C. nitida* (the kola nuts of commerce) may be red, intermediate shades of pink or white. The red are the most common; white are rare.

2. The colour of the nuts may vary from follicle to follicle, from tree to tree, and, on the same tree, from year to year.

3. The colour has been shown to be determined by the genetic constitution of the tree on which the flowers are borne and of the tree which yields the fertilizing pollen.

4. Trees grown from white nuts produce only white nuts when the flowers are self fertilized.

5. Trees grown from white nuts produce red, pink or white when the flowers are fertilized by pollen from trees grown from red nuts.

6. Crossing flowers from trees grown from red nuts with white pollen gave similar results.

7. A working hypothesis is that the absence of colour is a recessive character. Colour is determined by a number of genes and is complex. The closely parallel conclusions of Wellensiek working on cotyledon colour in cacao has been noted.

8. Out-pollination occurs in *C. nitida*. The carriers of the pollen are at present unknown, but a distance of 300 feet between trees is not sufficient to ensure isolation.

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RUSSIAN AGRICULTURE.

THE following notes are extracted from a summary of the Report of the 17th All-Union Congress which has been published (in Russian) in *Sozialisticheskoe Rastenievodstvo* (*Socialist Plant Industry*), *Ser. A, No.* 10 (1934). After enumerating the various scientific Institutes that have come into being in the U.S.S.R. since the revolution, the Report proceeds to give an account of the work that has been done and the progress made since 1930.

Cotton.—The amount of cotton produced in 1934 was 80 per cent. greater than that obtained in 1913. Although it was supposed to be impossible for cotton to be grown in the Northern Caucasus and Southern Ukraine, yet in 1934 the area under cultivation in those regions has amounted to 350,000 hectares. The Egyptian cotton grown in Azerbaidjan and Tadzhikistan is equal in quality to the best of that imported. The area devoted to Egyptian cotton in 1933 was 80,000 hectares. Special attention has been given to the mechanical harvesting of the crop.

Tea.—At the time of the revolution there were 900 hectares planted with tea in Georgia whilst in 1933 there were 34,000 hectares. Much research work has been carried out at the Tea Research Institute.

Sugar Beet.—In 1932 the area under sugar beet was 1.6 million hectares and the yield of sugar amounted to over 2.5 million tons. The waste from the sugar factory is used to some extent for fodder but might be employed for the production of dextrin.

Fruit and Vegetables.—Between 1929 and 1934 the area devoted to fruit and vegetables increased from 2 to 3 million hectares. Much research work is being done in the humid sub-tropics, especially with mandarins and grape-fruit. Other fruits which are being grown extensively include peaches, grapes, olives, almonds, pistache nuts and hazel nuts. Wild fruits occur in great variety in various regions and can be employed for grafting or hybridisation. These wild fruits can also be used for pulping and drying.

Other Crops.—Large areas have been planted with new crops, including sweet clover, sorghum, chicory, Jerusalem artichoke, sweet potato, &c. Soya beans are being cultivated in increasing quantities and the Soya Bean Institute has devised a method of preparing lactic products from the beans, which is now being developed on commercial lines in a factory at Moscow. A new form of lupin has been developed, which is free from alkaloids, and in 1934 more than 60 hectares have been planted with this variety.

Among fibre plants attention is being given to ramie, Italian hemp, kenaf (*Hibiscus cannabinus*), kendyr (*Apocynum* sp). and kanatnik (*Abutilon Avicennae*).

Other crops which have been introduced into the sub-tropical areas of the U.S.S.R. include Australian eucalyptus, wattle, cinchona, and the tung-oil tree which is being grown at Batoum. Work has also been started on sub-tropical fruits, such as the persimmon, guava and avocado. Several valuable rubber plants have been found in the Union and are now being grown in plantations. In the past about 12,000 to 15,000 tons of rubber were annually imported, but the demand is increasing greatly. It is hoped to increase the local supply by the manufacture of synthetic rubber from potato spirit.—(*Bull. Imp. Inst.*, Vol. XXXII, No. 3, 1934, pp. 433-435.)

TYPES OF AGRICULTURE IN THE NORTHERN SUDAN.

By F. E. Kenchington, M.Sc.

Introductory.

The Anglo-Egyptian Sudan covers a vast area across a considerable range of latitudes, and embraces a diversity of climates, peoples, and agricultures. The country may broadly be divided into three zones—the south where unaided precipitation is adequate and consistent enough to support pasturage, thorn forest, and crops—the arid north which without man's intervention remains almost completely sterile, and, between these two, a complete series of semi-arid transitional climates where rain crops are precarious, and expedients to make the best of the deficient precipitation desirable. In such a land of extreme tropical temperatures and wide diurnal variations, where rains are erratic, seasonal and deficient, water becomes the most insistent limiting factor. Thus, the evolution of existing types of agricultural enterprises has been based primarily on the exploitation of extra water either from rivers or wells, or by more primitive means, from the erratic rainfall.

Systems of Irrigation.

The irrigation of arid lands by water raised from wells or impounded from rivers is a practice centuries old in many countries. In the Sudan the major irrigation enterprise is that of the Gezira, the great flat triangular plain of heavy alkaline soil between the Blue and the White Nile, protected by the Blue Nile Dam at Sennar, whence its water derives by gravity-flow down canals upwards of 200 kilometres long. It is not intended here to give any account of that well-known enterprise, but rather of smaller, more primitive affairs which in the social organisation, the psychology, and economics of the native villages are of more direct if not of greater importance.

Irrigation by water from wells is little practised in the Sudan except upon tiny local areas. This is due to the almost universal lack of a generous water table close enough to the surface to be accessible by those primitive devices for raising water which are known to, and within the means of the average villager.

The Gash and the Baraka, two rivers of a considerable flow and volume (strictly limited however to a few summer months only of each year), derive from the summer rains of the mountains of Abyssinia and Eritrea, and coming down in spate expend themselves in deltas on the arid eastern plains of the northern Sudan. Some measure of control has been placed upon these summer floods by means of earthworks and channels so that considerable areas can be cropped at Kassala and Tokar. These are large-scale government enterprises devoted to cotton, with enough millet only for food for the native communities and forage for their stock.

The Nile Valley and Agricultures depending on its Water.

A hundred miles or so south from Khartoum the climate is such that good rain crops of grain can be expected four summers out of five so that the matters here to be treated are proper rather to Khartoum and the more northerly provinces, matters for the main stream of the Nile rather than its two main tributary branches. The general lie of the land and of its contours may be gauged from the accompanying sketch, which is greatly exaggerated, of the most typical cross section of that district. The Nile valley represents a very narrow flat, below the general level of the country which rises fairly sharply to the east and the west of it within quite short distances, and commonly in almost continuous rocky ledges or small hills. It suggests an ancient river at base-line of erosion or deposition phase although there are suggestions of a resumption, a phase of mild secondary erosion now in course. At Summer flood the swollen river rises to the level (B-B) indicated in the figure, 20 to 40 feet above low Nile level in spring (A-A) when the smaller flow occupies a shrunken channel meandering tortuously and changeably down the floor of the wide flood channel, between rocks, cataracts, sand-bars, and islands of all sizes, permanent and impermanent. The flood banks (B-B) are commonly somewhat above the adjacent land, which slopes gently down inland and then up again, so that it presents a gentle shallow depression with long axis roughly parallel to the river's course. These depressions are not continuous nor of universal occurrence: they may be of considerable width but more generally range between a half and a quarter of a mile across.

In some localities these depressions lie sufficiently below high flood level so that at flood season water may be admitted down a channel under control. This is held standing at some depth for a considerable period, and as it dries or is drained off, crops are sown round the wet slopes behind the receding water. These grow on the water stored in the soil, for no subsequent floodings during growth will be possible as the flood will have fallen. Thus was the manner of the great irrigations of Ancient Egypt before the modern era of perennial water from massive dams and large mechanical pumping plants. Although rapidly being made over into perennial irrigations these basin irrigations are still of great extent and importance in Egypt. In the Sudan they never attained great extent nor wide practice. Not only were they undesirable for reasons of malaria and bilharzia, but with the soils, the evaporation, and the temperatures of the Sudan it is mostly impossible to force enough water into the soil by a single initial flooding to bring a crop with certainty to profitable maturity.

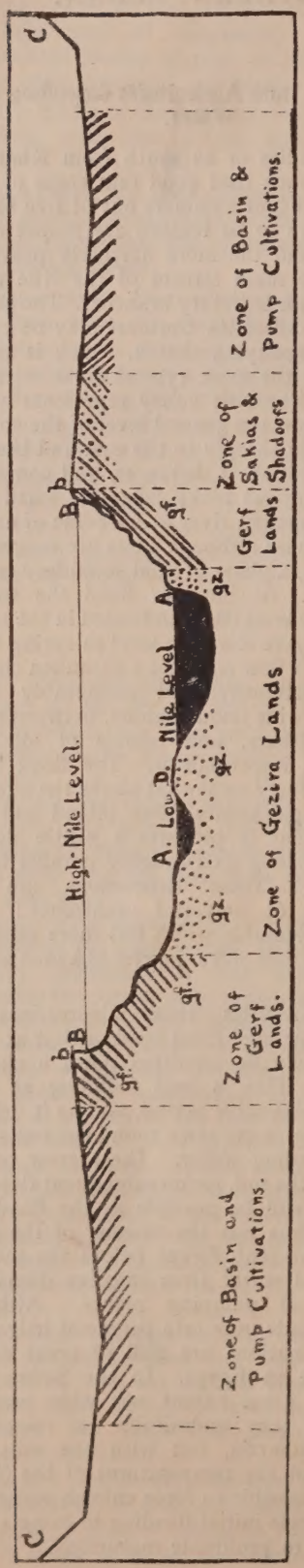

Diagram illustrating a Typical cross-section of the Nile and the Lie of the land in relation to various types of Sudan Agriculture.

KEY.—A A. Low-Nile channel.
B B. High-Nile channel.
C C. Rising land.
D. Sandbank in midstream

b b.—Flood-banks (natural lips of the channel at summer level).
gf. —Gerfs. A term loosely applied to these various types of situation.
gz. —Geziras. A term loosely applied to these various types of situation.

Pump Irrigations.

Considerable areas in these riverside flats and depressions have been brought under perennial irrigation by mechanical pumps with a fair measure of agricultural success, although economically the cost of pumping is an item which makes them rather dependent upon high prices for the products grown. Certain common limitations and difficulties of such enterprises arise from the differences between flood and low river level, necessitating either a mobile or an adjustable plant, also frequent stoppages for adjustment. Erosion of banks at flood, the silting of intake wells or channels, and changes of channels and sandbanks at low-river are unpredictable matters of normal expectation, often leading to capital losses. Difficulties at the landward side are rising contours, areas of useless soil, and legal complications. Here by Mohammedan laws of inheritance, holdings are split down to a few acres or perches, after which joint ownership comes in, so that the individual consent of four or five co-owners may be necessary at each decision affecting any little patch of ground.

A number of the larger pump-schemes with cotton as a main crop are Government enterprises, others are capitalized by Europeans, Levantines and wealthier Sudanese, and worked largely by hired labour. Many are partly or wholly operated on crop-sharing terms as between capitalist and native tenant-cultivator. At the lower end of the scale comes a rag-tag and bob-tail of smaller enterprises watered by fifth-hand queer old adapted steam or oil plants, masses of improvisations after the manner of Heath-Robinson, and here pump schemes begin to enter the orbit of all-native enterprise. The disastrous fall and sustained low level of cotton prices since 1929 forced the curtailment or cessation of operation of many of these pump-estates pending better times.

As the flood declines the lift and other difficulties of pumping increase so that ill-sited or low efficiency pump outfits become ineffective. There are thus two classes of pump-irrigations. Nile water is a precious commodity, limited and somewhat erratic in volume: its use is therefore subject to legal control under agreements between the governments concerned. A license must be approved and purchased before the enterprise can begin. One class is licensed to draw water only at the season when the volume of the river is high (Mid-July till the end of February) while the other is licensed to pump the whole year through. Subject to reasonable enquiries, licenses for limited seasonal pumping only at high river are comparatively readily granted. Permanent licenses permitting perennial pumping are approved only after the strictest scrutiny, especially if the proposed pump exceed six inches in bore, for the diminished flow at low-Nile is guarded by stringent agreements between governments, defined limits, and compensation clauses. The period March to June inclusive

during which seasonal licenses may not pump has the worst climate of the year and is useless for crop growth so that the writer has always been somewhat at a loss to account for the higher value attached by petitioners to the perennial type of licence, except where perennial fruits are to be planted.

Native Irrigation.

Native irrigation proper is embodied in the *sakia* (ox-power waterwheel) and the *shadoof* (man-power sweep or water hoist), two primitive mechanisms unchanged since the Pharaohs. A *sakia* involves, apart from land at the river's brink, a capital outlay of between £20 and £60 which is represented by cost of wood, erection by the village carpenter, and two or three pairs of working bulls. A *shadoof* represents probably less than £1 cash but involves prolonged monotonous labour in operation, for the water is hand-hoisted and poured bucket by bucket. The construction, operation and maintenance of these devices is well understood by the villagers and they involve no immediate disbursement in cash of considerable sums. Needing only local materials skill and labour, credit is a local matter between friends, and they can be kept efficiently running by the native. The wages problem hardly arises for these are family affairs. Contrast all this with the heavy capital cost of pumping machinery, the cash expenditure for fuel oil, spares and mechanical requisites, the highly paid more or less skilled labour, the intractability of metal parts, seldom repairable in the village and speedily in case of breakdown, all of which are for the native implicit in the mechanical pumps.

The *sakia* can protect a total of roughly five feddans or acres for each shift pair of oxen employed, so that operating day and night with three shifts of oxen its limit is rather under 15 acres. The *shadoof* protects roughly an acre. In general practice the limit of profitable lift for the *sakia* seems to be about 25 to 30 feet, that of the *shadoof* 8 to 12 feet. These devices are sometimes worked in series, a collecting pit being made at the limit of flow of the water raised by the first, whence the second lifts water to still higher levels. Mechanically crude as they are, and limited in range and performance, these devices are yet surprisingly efficient within their proper scope. Economic enquiries have shown them superior to poor types of mechanical plant although scarcely equal to the better types, in terms of water delivered per unit of cost. Thus almost anywhere along the river edges where the river runs close under a cliff-like bank, or where the foreshore is such that ample intake water can be maintained in a cutting or a pit under the mechanism, there is or has been a continuous row of *sakias*, a narrow irregular strip up to 150 or 200 yards in width. In some places the pump schemes have absorbed this riverside fringe of *sakias*, supplying the water and sharing the crops, but in others the fringe of *sakias* persists unaffected by the modern operations in the depression behind them. This purely native and ancient agriculture has scarcely altered for centuries with its highly evolved code of operation, tenure and crop-sharing systems, joint or divided ownerships, limitations and difficulties. One feels that in it might often be found the key to understanding the riverain Sudanese. It is often at the root of his conservatism and apparent illogic. Its limitations have for ages conditioned his thoughts, so that he is often honestly unable really to grasp or trust new ways and their reasoning when modern resources enable them to override the ancient limitations.

Gerfs and Geziras.

When the flood declines terraces and slopes of wet new silt emerge from the water "between the tide marks". The high level bordages, flooded only in years of extra heavy flood are called *gerfs*, a word often extended roughly to the upper half of these areas between the two river levels, or sometimes to any steeply sloped section thereof, irrespective of its relative elevation. The term *gezira*, properly applied to islands and sandbanks, is also applied to sandy beaches and spits, and to the lower or flatter stretches of these yearly flooded strips. *Gerfs* and *geziras* represent something almost for nothing, crops without tillage, weeding or irrigation, and are the jealously prized assets of the riverain villages to which they belong. They are the subject of an ancient and intricate code of Mohammedan law, often far from obvious to our way of thinking, and which governs their ownership, partition and changes in site, size and shape. Thus if one autumn the falling flood reveals that the sandbank previously enjoyed by village A, no longer exists, but that perhaps six or eight miles downstream a new one has appeared, perhaps on the frontage of village B, which one might expect to be celebrating a windfall, then that sandbank is held the truant property of village A, and its owners daily trek to and fro to work it.

Soils.

There is naturally a deal of local variation but in rough general terms the soil of *geziras* are generally sand, sometimes thinly crusted or shallowly, interbedded with thin sheets of gravel or clayey mud. Between "the tidemarks" gravels and clays are encountered, but the soil is mostly porous well-drained new silts or loams, and the soil of *gerfs* proper is an even loamy silt which makes fair bricks and pots. This too is the general character of the soils on the flood-banks, proper to the *sakias* and *shadoofs*, although these often have rather more clay and less sand in their mixture. The flats and basins are generally of much finer texture, heavier, darker soils, generally alkaline, sometimes salty, being heavy loams or else extremely heavy clays.

Crops and Tillage.

The larger pump schemes are tilled, cropped, and weeded with some care, although considerable persuasion and driving are often necessary to maintain this standard. Cotton is the crop which really matters, rotations are short and

somewhat elastic including usually a dry bare-fallow year, and just as little grain straw and leguminous forage (*dolichos lablab*) as will meet the needs of natives and necessary livestock. On *sakias* a considerable amount of cotton was grown when prices were good. They included then, and much more so now, a considerable proportion of *durra* (greater millet) or wheat, and of forages such as *dolichos lablab* and *vigna sinensis*. They are generally, to avoid levelling and to control the watering, broken up into numerous small plats or beds a few yards square, each surrounded with its earthen ridge. They present a patchwork appearance, a large mixed collection of a variety of crops in little squares, sorts often little known or appreciated by the European, but desirable in the native way of life. These may include a selection from the following: forages such as lucerne, *dolichos* and *vigna*; pulses such as lentils, chick-pea, groundnut, cowpea, beans of the *phaseolus* and the *vicia* genera; salads and vegetables such as tomato, aubergine, onion, garlic, portulaca, okra, chinese radish, spinach-beet, native cucumbers, pumpkins and gourds, and various less known native potherbs of rank flavour. Some enterprising growers near towns grow a few European vegetables such as cabbage, lettuce, radish, carrot, beet and spinach for sale. Fruits such as limes, guavas, custard apples, oranges, pomegranates and bananas are also rather badly and unsuccessfully grown to a small extent, mostly for the owners' use in general; while dates and melons are oftener and more successfully cropped. Miscellaneous herbs used in native medicine, cookery and perfumery also appear such as *capsicum* (spp. *minimus* and *frutescens*) mint, fennel, aniseed, caraway, coriander, *hibiscus sabdariffa*, thornapple (*datura*) and many more are generally to be noted. The above lists are by no means exhaustive. The wheats grown are mixed local sorts, dwarf, bearded, and attributable to the *durum turgidum* and *pyramidalis* groups mainly, while a similar looking heavily bearded free tillering six-rowed barley is also to be found.

The *gerf* and *gezira* lands are hardly cultivations since neither tillage nor irrigation is needed. Seeds are sown and covered in holes made at fairly regular intervals with a peculiar form of sowing stick called a *seluka*, in the wet silt exposed by the falling river. These new deposits being practically free of sundry spores, weed-seeds and pests such as abound on the dry lands proper, it is possible to grow profitably there certain crops which are usually unsuccessful elsewhere, notably melons (both musk and water), cucumbers, marrows, pumpkins and gourds. Hardly any weeding is necessary, manure is given in rare localities to the melons. It remains only to gather the produce, trusting to providence that the fall of the river is slow and regular, without late freshets and rises to drown the seedlings, nor yet too rapid so that the part-grown crops dry off in unprofitable immaturity. Some wheat or barley is sometimes grown but apart from the cucurbitaceous crops mentioned, the typical crops of these lands are maize, tomato, bulrush-millet, pigeon peas, *dolichos* and *vigna*.

Agriculture dependent on Deficient Rains.

Various plans have at various times been worked for controlling, collecting and conserving the run-off, which is considerable on the heavy soils mostly prevalent away from the rivers, for deficient and unreliable as the rains are, they are confined to a brief season and fall rather in heavy storms and downpours. The year to year fluctuation in precipitation is extremely wide as well as erratic so that even to the north of Khartoum, where the average rainfall is under five inches per annum, perhaps one year in ten an exceptionally wet season of ten or even 13 inches rainfall may make it possible to ripen a grain crop, at any rate on the depressions or lower lying flats where run-off may further supplement the moisture. Thus it is, that, although nine years out of ten the rains take off before the millet has even come to ear, so that no more than a scanty crop of strawy trash suitable for forage is to be expected, yet year after year the inhabitants take a long-odds gamble on the rainfall and sow up the suitable low lying areas. As one goes further south one travels into heavier rainfalls where crops will succeed, barring locusts, pests or other act of God, one year in three, four years in five, then nine years in ten. Thus most of the land, barren and useless as it may look, even up to several days' trek from permanent water has some sort of speculative value and is found on enquiry to have an owner with title under the local traditional land code.

The natural basins, depressions and collection areas, where run-off from the surrounding slopes supplements precipitation, are known and valued. In the zone between Khartoum and Sennar, where rainfall grades up from 5 to about 15 inches per annum, and where there remains some element of uncertainty as to either the amount or of the duration of the rains, it is customary to surround the areas to be sown under millet with large ridges or small banks of earth called *tarasses* which prevent the escape of run-off water. Khors or depressions naturally or artificially banked off have served to collect and retain water and the wet verges behind the receding water have been planted, or even used as reservoirs from which the water has been led under control to supply a crop, started in the rains, with the final extra wetting or two; necessary to ensure its coming to maturity. Similarly, in suitable places, especially at the foot of hills and rising or rocky ground, collection ponds and pits called *hafirs* are even now constructed, but their purpose is to store water not for cultivation but for the drinking of the villagers, the nomad tribes, and the flocks and herds. This country of dried up thorn scrub, with ephemeral summer grasses and weeds, can support a surprising stock of cattle, camels, goats and sheep provided they can be watered. They can even thrive drinking only

every 40 to 50 hours, for given a full drink one morning, they can be marched all day inland to the grazing and there spend the night. On the following day they graze and march back, arriving at the drinking place for a full drink at evening.

The rainfall increases to the southwards and with it the size of the thorn bush and the seasonal herb vegetation. Here the natural depressions, called *maiyas*, are pools holding water for perhaps eight months of the year. They afford scope for cropping which is sometimes undertaken but mostly not, for they require appreciable cleaning and weeding, and are the resort of game. Moreover the country there is more sparsely inhabited and there are extensive flats suitable to the less laborious rains-crop, sown without tillage by the *saluka*.

In most of these conditions the cultivation is primitive and lazy. It consists mainly of sowing and harvesting, the rest being mostly left to Nature. Some half-hearted hoeing gets done in the drier northern parts. The not very luxuriant nor copious annual weeds occurring there are hardly likely to the Sudanese mind to appear a cogent reason for the exertion, so that some vague idea of tilth-mulching to conserve moisture may underlie it. Good cultivators in the belt where *durra* is generally enclosed by *tarrass* ridges give two or even three weedings, but poorer cultivators are sadly prevalent. Further south still weedings are more urgently needed and, experience suggests, less freely performed. Weeding is an exertion about the principle of which the Sudani generally is not altogether sound. He weeds as a convention, or in response to the importunings of say the superintending official, rather than from conviction or principle. His feeling is that weeds in moderation and within reason do no appreciable harm to a crop. It will take long really to convince him to the contrary, especially as it involves labour of an unexciting sort, and as he is instinctively warmer towards the idea of utilising the weeds for forage for his donkeys or milch ewes. Weeds cut out are commonly laid into neat bundles and carried home, and for this he feels it is as well to let them first grow into something worth taking home.

The major crop under these rain conditions is the greater millet. On the light porous sand soils to the west, bulrush millet largely replaces it. Both are comparatively tolerant, it is true, of weeds of the dicotyledonous orders. As one moves further south cotton and sesame are increasingly grown, coming eventually into the true rain-cotton belt in Mongalla, Upper Nile and Southern Kordofan. These crops are far less tolerant of sketchy weeding.

REVIEW.

SORAUER (P). HANDBUCH DER PFLANZEN-KRANKHEITEN.

(Handboook of Plant Diseases. Volume I. The non-parasitic and virus diseases. Part I, 1933, 46 Rm; Part II, 1934, 44 Rm; Sixth revised edition. Volume II. The Vegetable Parasites. Part I, Fifth revised edition 1928, 48.60 Rm; Volume III. The Vegetable Parasites. Part II, 66 Rm; Fifth revised edition, 1932). *Paul Parey*, Berlin.

In these days of rapid expansion in the field of plant pathology, the revised and greatly amplified editions of Sorauer's well-known and attractively produced work raise the interesting question as to what degree of completeness one may reasonably expect in even the most comprehensively planned work. It seems inevitable that the specialist worker, on referring to particular sections, will discover weaknesses of treatment and even omission in what may be considered scientifically noteworthy. In considering a work such as this, it is essential that the reader should bear in mind what a hand-book claims to do. It is, in fact, a manual or guide to a subject, but does not necessarily lay claim to factual finality. What is really important, therefore, is that the point of view and treatment of the subject matter should have the right orientation and should be up-to-date. Judged by these criteria, the new editions of Sorauer's Handbook should commend themselves to the student and the working plant pathologist. In this connection Part I of Volume I (The non-parasitic and virus diseases) may be cited in illustration. Here, in general terms, diseases of plants are dealt with under such headings as nature, symptoms and causation, including a discussion of those environmental factors important in the development of pathological conditions; other sections deal with the relation between nutrition and disease and include disorders due to metabolic causes, mineral deficiencies, and to climatic, meteorological and physical factors. In Part II, non-parasitic plant diseases caused by internal factors and unfavourable physical and chemical soil conditions, are considered. The parts played by wounds, of whatever source, and by wound-reaction are likewise surveyed. This book also contains a comprehensive account of the virus diseases.

Volumes II and III are substantial works dealing in considerable detail with diseases caused by plant parasites—bacteria and fungi chiefly but also with briefer sections on algae, lichens and phanerogams. Without referring to particular sections, for to catalogue them would be to fill a column, it may be said that the treatment throughout is thorough, sustained, and well documented.

The new editions of Sorauer's Handbook as revised by Dr. O. Appel and his colleagues may be commended as probably the best treatises of their kind and should find a place in the libraries of pathologists and scientific agriculturists alike.

C. W. W.

THE VEGETATIVE PROPAGATION OF CACAO.*

E. E. Cheesman.
Imperial College of Tropical Agriculture, Trinidad, B.W.I.

Historical Introduction.

Credit for the first successful attempt on record to propagate cacao asexually belongs to J. H. Hart, who in 1898 exhibited before the Agricultural Society of Trinidad and Tobago several plants grafted by approach (inarched) on seedling stocks. From that date onward the literature bears witness to a lively interest in the subject in several cacao-growing countries.

In Dominica, J. Jones (1) succeeded with the same grafting method in 1906, after attempts in the previous year to graft cacao scions on *Theobroma bicolor* had failed. Parenthetically it may be mentioned that later attempts to use *Th. bicolor* as a stock for cacao have failed in Trinidad and Surinam, and there are no records of success elsewhere

Meanwhile in Jamaica, Harris (2) had demonstrated in 1903 the possibility of another method, by patch-budding on vigorous sucker shoots from the bases of old trees. In Java, Heyl, according to van Hall (3), budded cacao at about the same time, and van Gent later tried various methods of grafting and budding. In Haiti, Casse (4) had success in 1906, budding on young trees 1½ to 2 years old, and 0.5 inch or more in diameter. In the Philippines, Wester (5) in 1911 had good results with shield-budding on seedling stocks 20-25 mm. in diameter.

Jones (6) in reporting later experiments in Dominica, advocated trials of budding on young seedlings, to obviate the erection of staging round the parent tree, as in inarching and to enable the whole process to be carried through in a nursery. In 1915 he reported success in budding on seedlings in bamboo pots (7).

In Trinidad work had been independently following lines similar to those in Dominica, and in 1913 Freeman (8), reviewing past efforts to bud cacao, reported successes by J. C. Augustus with 16 plants in bamboo pots out of 40 attempts. By the next year the Trinidad Department of Agriculture had established the technique sufficiently to warrant the laying down of an experiment to compare budded, grafted and seedling trees from the same parents under plantation conditions. Details of the experiment are given by Freeman (9). It involved the planting of four acres of vegetatively propagated trees, which are still extant and interesting as the first trees of such a nature ever planted on any considerable scale. A little later, another experiment was laid down to compare methods of replacing poor bearing trees in established fields, and one of the methods included was to cut the poor bearers down close to the ground, and bud on the suckers developing from the stump. Williams (10), in 1917, had excellent results from budding on suckers, the rate of growth of the buds being six inches a month. Subsequent experience, however, revealed a tendency for the suckers to break away from the stump, which led to the abandonment of the method for plantation purposes.

In Surinam, Stahel has evolved a budding technique which is described by van Hall (loc. cit). It differs from that used in Trinidad in the employment of larger stocks and a different type of bud. In general, budding has everywhere supplanted grafting as a more convenient and economical method.

It is noteworthy that all the investigators contributing to the perfection of the budding technique in different countries were inspired by the advantages to be derived from the cultivation of uniform types of cacao, in place of the heterogeneous seedling populations which are still the rule. Some mentioned earlier bearing as an additional point in favour of budded trees, but all stressed uniformity, and especially uniformity of high yielding power, as the great desideratum.

In quest of uniformity all attempted, quite rightly, to adapt to cacao horticultural methods long established for temperate orchard crops; but in quite recent years temperate orchard practice in this respect has again moved ahead. Researches, in which the East Malling Station has taken a leading part, have shown that uniformity of yield and of other characters in temperate fruit trees depends on uniformity of rootstock as well as uniformity of scion. There is no reason *a priori* to suppose that these findings will not apply to cacao, but rather the reverse.

For this reason, when in 1930 a Cacao Research Scheme was launched at the Imperial College of Tropical Agriculture, it was felt necessary to approach the problems of vegetative propagation from a new angle. There were many problems relating to budding still awaiting solution, but it was decided to concentrate attention, so far as the propagation side of the programme was concerned, on efforts to raise cacao trees vegetatively *on their own roots*. The numerous problems of stock-scion interactions could the more profitably be deferred for later attack because in the absence of clonal rootstocks the most promising instrument for their solution was not yet available. A summary of the results achieved and of the present outlook is the object of this paper, but, in order to explain the terminology which must be employed, a brief description of the mode of branching of the cacao tree must be given first.

* Reproduced from the *Empire Journal of Experimental Agriculture*," Vol. II, No. 5, by kind permission of the Editor.

Branching of the Cacao Tree.

A young cacao seedling growing healthily produces a single vertical unbranched stem, on which the leaves are arranged in a $\frac{2}{5}$ spiral, and which later forms the *main trunk* of the tree. After a variable time, and presumably when it has attained a certain physiological condition not yet defined, the terminal bud divides into three, four, or five, which grow out into oblique or almost horizontal branches (Fig. 1). The whorl of branches so formed is known as the *fan* or by the Trinidad term *jorquette* (pronounced *horkette*), the latter name being preferable, because the word *fan* or *fan-branch* can then be used for the individual limbs of the jorquette without danger of confusion. The fan branches have their leaves in two ranks, and bear secondary branches of higher orders, all with leaves in two ranks.

At a later stage a vertical branch arises from the main trunk just below the jorquette. Since it arises on old wood, there is difficulty in determining its exact origin, but it is probably axillary. This branch is known as a *chupon*; it has its leaves in a spiral, and it repeats exactly the behaviour of the seedling axis, growing up through the jorquette and in due course branching into a second jorquette some feet higher. A third and fourth tier may be added to the tree in the same way. The arrangement is often obscured in old trees by loss of the lower branches by reduction of the vertical part of one 'storey'

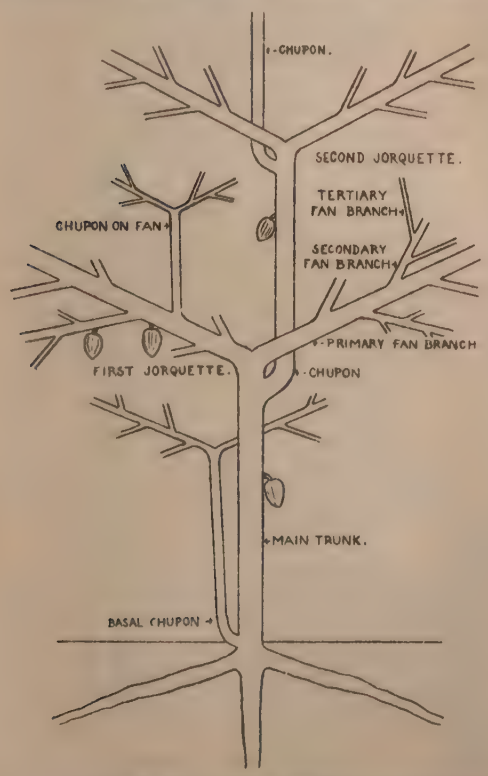

FIG. 1.—*Diagrammatic Representation of the Branch System of Cacao.*

so that two jorquettes arise from almost the same point, or in other ways, but it can usually be traced on careful examination.

As the tree grows older, it nearly always produces from the base of the trunk, at or near ground level, additional chupons (also referred to as 'suckers', 'water-shoots', or 'gormandizers') and if left untended may develop into a clump. In cultivation these basal chupons are most commonly cut out, though some planters like to leave two or three. If the original tree is showing signs of disease or senility, it is usual to allow a strong chupon to grow, and when it is in a condition to replace the old trunk to cut out the latter instead. For this reason 'age' in cacao fields is a complex subject, since an old tree, said to be of a certain age, may have been renewed (so far as the parts above ground are concerned, and probably in roots as well) several times since the actual planting.

Normally chupons do not branch, except when they make their jorquette, but they may be induced to do so by bending them over or cutting them back, and when the axillary buds are thus stimulated into growth they give rise in every case to branches of the same type, *i.e.*, to chupons. Fan branches on the other hand branch freely, and their axillary buds likewise normally produce shoots like themselves, *i.e.*, fan branches of the second or higher orders. If, however, fan branches are cut hard back they will sometimes produce chupons behind the cut. Moreover, it is by no means uncommon in the field to find chupons arising from fans, and although the physiological equivalent of pruning, in the shape of a wound or canker, can often be found as the cause, such is not invariably the case.

The so-called 'dimorphism' of cacao branches is thus clearly marked, yet by no means absolute and there seems to be a certain plasticity of behaviour in both kinds of buds. Buds on fan branches (*fan buds*) especially seem able to give rise to either fans or chupons, according to their physiological state, and shoots may be found on fan branches having a spiral phyllotaxis below and a two-ranked arrangement above. Axillary buds on chupons are less plastic, but physiological factors must certainly determine the height at which the terminal chupon bud produces its jorquette, since that height varies without any apparent morphological or genetic reason.

The practical importance of the dimorphism in propagation lies in the fact that the entire habit of the vegetative progeny depends on the type of branch or bud used. Thus in the early grafting experiments, fan branches were inarched on seedlings held in bamboo pots near the tree, and Jones describes his grafted plants as branching a few inches above the point of union and forming bushy specimens. In the budding method described as used in Jamaica and Haiti, trees were pruned to provide vigorous chupons for budwood and the result, as shown by Casse's photographs (4), was that the budded progeny

developed a main trunk. The same applies to Stahel's technique, in which chupon buds are recommended as preferable. In Trinidad, however, fan buds have usually been employed, and as a result budded plants can be recognized at a glance by their lack of trunk, and by their spreading, two-ranked branches, which need some training to make a symmetrical tree. It is to be noted that whereas there is always an abundance of fan material available on a healthy tree, there is very often under plantation conditions, little or no chupon material to be had without recourse to manipulation. Exactly the same considerations apply in propagation of scions on their own roots.

Propagation by Cuttings.

The rooting of cacao cuttings has possibly been achieved, though unrecorded, many times in different countries, but it has never previously attracted attention as an important contribution to the technique of crop improvement. Since the end of 1930, however, a systematic survey of the possibilities of the method has been made by E. E. Pyke, working in these laboratories, and the conclusions here given are based entirely on his researches. Detailed accounts have appeared elsewhere (11, 12) and only a summary will be attempted.

The work began with a general survey of all possible means of vegetative propagation, excluding budding and grafting. This included trials with hardwood and softwood stem-cuttings and root-cuttings, and soon demonstrated beyond doubt that between those the greatest hope of success lay in the use of softwood. By 'softwood' is meant shoots that are mature but which still retain their leaves, and which are set to generate a root-system without removal or loss of those leaves; in actual texture such shoots are semi-hardwood. The success with this kind of cutting was of such an order that there appeared to be no possible economic advantage in pursuing investigations with hardwood, and subsequent work was devoted to standardization of method.

The second year's work established several principles. In the first place it showed an important connexion between the physiological condition of a tree and the behaviour of cuttings taken from it. Old trees and trees grown without shade are alike unsuitable for supplying cuttings. The general appearance of shoots likely to root well is now known, but much physiological research remains to be done before the constitutional features of such material can be defined. In the second place comparisons were made between chupon cuttings and fan cuttings, which showed little difference in ability to root, but marked differences in the type of rooting and subsequent growth. In both, the roots push horizontally, through the cortical tissues just above the callus but whereas in fan cuttings they continue to grow almost horizontally for some centimetres, in chupon cuttings they usually turn vertically down as soon as they emerge from the stem. In fans, the terminal bud, if present, usually grows out, together with several lateral buds, sometimes low on the stem, and the shoots tend to spread obliquely. In chupons, on the other hand, either the terminal bud, or in its absence a single lateral near the top of the cutting, grows out into a vertical leading shoot. The differences are illustrated by Fig. 2. The chupons, as might be expected, approximate more closely to seedlings in their behaviour, and the importance of that fact will be indicated later.

The essence of success with softwood cuttings lies, as every horticulturist knows, in keeping the leaves on until roots are formed, and to that end careful control must be exercised over both the water-content of the rooting medium and the humidity of the air above. Illumination is also important, since much of the carbohydrate used in root-formation is presumably manufactured by the cuttings after they are set in the propagator. Temperature under Trinidad conditions needs no elaborate control, and none was attempted, since the object of the researches was less to discover academically optimum conditions than to establish the simplest technique consistent with practical results.

Full details of the propagating frames used and of the environmental factors studied are given by Pyke (loc. cit.). In average batches of cuttings, 50 per cent. root within three weeks, and good batches finally show 90 per cent. or more of successes. These figures justify the claim that

FIG. 2.—*A—Typical Fan Cutting. B—Typical Chupon Cutting. (New growth only shown; old leaves omitted for simplification of diagram.)*

a practicable technique has in fact been found. Subsequent treatment needs care if the rooted cuttings are to be successfully established in the field, but presents no very great difficulties.

Propagation by Layering.

Stooling and layering were tried simultaneously with the experiments on cuttings, and with equal success.

Aerial layering, or marcotting, in which ring-barked branches are surrounded by a ball of moist soil in sacking, has been found possible with cacao in Trinidad, Ceylon and Java, and is illustrated by van Hall (loc cit.). It is, however, a tedious method and for large-scale work possesses no apparent advantages over the setting of cuttings.

Pyke obtained excellent results by pegging down seedlings about 18 months old in the surface of the soil. Basal chupons of older trees, if they occur in a suitable position and are at the right stage, can be treated similarly. Under such treatment several of the axillary buds push out into vigorous chupon branches, and if they are then moulded up with soil they develop in a few months a strong root-system with one or more main roots running vertically down like tap-roots. Earthing up must be deferred until the buds have made some growth, because cacao buds apparently will not burst when covered, and all attempts with covered layers failed. Secondary layers were at a later date made from the first with equal or even greater ease.

The observations are still incomplete in the sense that established cuttings have not yet been layered, that step being on this year's programme, but there appears no reason why chupon cuttings at least should not behave exactly like seedlings in this respect. Fan branches similarly laid down have so far given rise to fan-type layers, and fan cuttings may be expected to do the same. It is in layering of fans, however, that the plasticity of the buds assumes importance. It is most probable that by cutting hard back after rooting, or by some other manipulation, chupons can be induced on fan layers. Work is at present being directed towards finding the appropriate treatment for converting fans into chupons with certainty.

The possible advantages of layering lie chiefly in the ease of the process, and the fact that constant daily attention is not required by a layer-bed, as it is by a propagating frame set with cuttings. On this account the layering technique may prove more adaptable to estate routine and provides a means for the planter to bulk up an approved clone from rooted cuttings initially supplied by an experimental station. The possible disadvantages are the length of time required for rooting and the rather large space taken up by a layer nursery as compared with a seedling nursery. Much remains to be discovered about the minimum time in which layers can be induced to root, and also about the number of rooted branches which can be obtained per unit length of stem laid down. Until these points are determined the method can neither be recommended for commercial use, nor accurately compared with the cutting technique in efficiency and practicability. Still, from the point of view of practical nursery multiplication, the outlook is the more promising for the existence of these alternative methods.

Stooling by a method similar to that used for Malling apple stocks has been tried, but so far has given results inferior to those from layering, chiefly because the shoots seem to need ring-barking to induce deep rooting, and the extra handling involved has no compensating advantage. It remains to be seen whether older stools will behave differently, and no final pronouncement on the relative merits of the two methods is yet possible.

Established Potentialities.

With the striking of cuttings and rooting of layers added to the previously established method of budding, there is now at the disposal of the research worker an almost complete range of possibilities of producing any kind of tree he chooses. A tree selected in the field by the plant-breeder as worthy of clonal multiplication may be grafted or budded on a seedling stock, or cuttings or layers may be taken from either its fan branches or its chupons, according to the circumstances, the facilities and the type of material most readily available on the tree. Once established in the experiment station, any type of tree can be converted into almost any other. Grafts or buddings can be subsequently layered or used as a source of cuttings. Chupon-type plants will always produce sooner or later a jorquette of fan branches. The only gap in the chain is the absence of a sure method for obtaining chupons at will on fan-type plants, and it has been shown that this problem does not seem by any means insoluble. In short, isolation of any desired clone *on its own roots* becomes a matter of routine, and the main question next for solution is, which of the several methods of propagation available can be most advantageously adapted to the raising of planting material on a commercial scale. This question, however, involves at least three subsidiary ones of the greatest importance, which must be shortly discussed.

Outstanding Problems.

Ruling out grafting, which by the consensus of opinion of previous workers is less convenient than budding if seedling stocks are to be used, and ignoring any possible differences between cuttings and layers as means of propagating clones on their own roots, there are still six distinct kinds of vegetatively propagated cacao trees which now need careful study and comparison. They are illustrated diagrammatically in Fig. 3, which represents, from left to right:

Type IA, fan bud on seedling stock; IB, chupon bud on seedling stock.

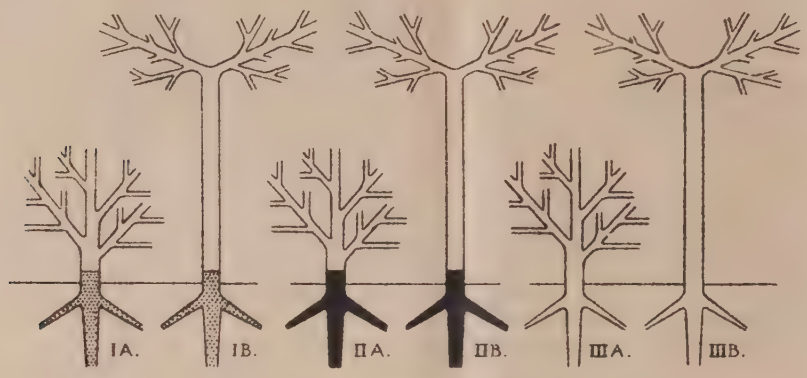

FIG. 3.—*Types of vegetatively propagated Cacao trees:*
I. Budded on seedling stock. A. Fan bud. B. Chupon trees.
II. Budded on clonal stock. A. Fan bud. B. Chupon bud.
III. Unworked. A. Fan cutting or layer. B. Chupon cutting or layer.

Type IIA, fan bud on clonal stock; IIB, chupon bud on clonal stock.

Type IIIA, fan layer; IIIB, chupon layer.

The three major questions to be answered, in order of importance and urgency, are: (i) Should the root-system be of seedling or of vegetative origin? (Type I versus Types II and III) (ii) Should the root-system and the scion be of different genotype or identical? (Types I and II versus Type III.) (iii) Should the scion be of fan or chupon origin? (Sub-type A versus sub-type B throughout). Only experiment can provide the answers, and it may well provide different answers under different sets of conditions. There are, however, a number of considerations bearing on each of the questions which must be reviewed even at the present stage, because they indicate the relative magnitudes of the issues involved.

(1) *Root-systems.*

The drawbacks of seedling stocks for temperate fruit trees are too well known to need more than mention. They arise from the fact that the parent trees from which the seedlings are raised are heterozygous, so that the seedlings themselves vary in constitution one from another, and the composite trees of which they form part after grafting or budding must likewise vary. The variations in yield and in other physiological behaviour of uniform scions when united with such variable stocks are of great economic significance, and it has come to be realized that if orchard material is to be truly standardized, stocks raised vegetatively must be used.

Similar drawbacks of seedling stocks for cacao are at present only assumed by analogy. Seedling cacao stocks are indubitably heterogeneous, and the argument by analogy is justifiable as a working hypothesis until disproved. A direct demonstration is difficult, first because there is so little budded cacao of which records have been kept, and secondly because there have until now been no clonal stocks to serve as standards of comparison. What little direct evidence there is does not contradict the hypothesis. Still, the direct demonstration must be provided before further work can be well and truly founded on a scientific basis.

On the other side of the account, there is a strong prejudice in many quarters in the tropics against trees on non-seedling root-systems. It is said that the absence of a tap-root makes them liable to fall in wind and otherwise militates against their efficiency. Such an argument must be respected and put to experimental test. That it may be true, yet only half true, is shown by Fig. 2, illustrating the essential differences which may arise among vegetatively induced root-systems themselves. At the present it seems likely that cacao stocks raised from fan cuttings or fan layers might be genuinely open to objection, whilst those raised from chupon cuttings or chupon layers might not. Steps are being taken immediately to compare both types very carefully with seedlings, but it must inevitably be some years before conclusive results can be obtained, and meanwhile other investigations must be pushed ahead on the presumption of an answer favourable to clonal stocks.

(2) *Composition of tree.*

Assuming for the purposes of argument that vegetative stocks can be proven better than seedlings, the question at once arises whether budding remains any longer necessary or desirable. Budding of selected scions on selected clonal stocks would be directly analogous to the most advanced practice in temperate fruit culture, but it need not necessarily prove ideal for cacao, and this is a case where argument from analogy can easily be carried too far.

Cacao trees selected for propagation will usually be selected primarily for high-yielding power, and only secondarily for qualitative characters of the fruit. In this respect they are not quite comparable with fruit varieties, which have probably in most cases been selected primarily for non-yield characters such as flavour, texture, or size of the individual fruit, and only secondarily for yield per tree. The high-yielding cacao tree must have a root-system capable of supporting its yield, and if cuttings or layers from it regenerate a root-system of similar type, the main object of vegetative propagation will be attained.

It is not overlooked that a scion good on its own root-system might give even better results than its parent if placed on another; neither have the possible uses of different stocks to change the habit of the scion been forgotten. Dwarfing stocks, for example, might be very valuable for 'filler' trees in laying out new plantations at a wider spacing of the 'permanent' trees. There is, indeed, scarcely any limit to the amount of research which will be needed into the interaction of stocks and scions in cacao culture, now that clonal stocks are available for accurate studies.

At the same time there is a factor of quite another kind which cannot be excluded from this part of the discussion, and that is disease. Canker (caused by *Phytophthora Faberi* Maublanc) is one of the most destructive of diseases of cacao, and causes incalculable losses. It is one of the advantages of the seedling cacao tree that, should the main trunk or jorquette be badly attacked, the whole system can be regenerated by allowing a basal chupon to grow, and it has been pointed out above that this practice is regularly followed. A budded tree naturally cannot be regenerated in similar fashion, because if a basal chupon grows it is of the stock and not the scion variety. A tree from a layer, however, will behave in this respect like a seedling. The natural regenerative power of the cacao tree is a valuable economic asset not shared to the same extent by the majority of species usually budded or grafted, and may possibly prove the deciding factor between 'foreign' and 'self' root-systems, at least in many districts where canker is especially rife.

(3) *Branch-systems.*

It has already been hinted that if layers (Type III) should ultimately prove the most satisfactory means of propagation, as on the balance of available evidence seems not unlikely, the choice between fan and chupon material for multiplication is likely to be decided by the nature of the respective root-systems. If, however, trees of Type I or Type II prove preferable, the question of branch-systems will add itself to the more urgent ones already discussed.

On account of the cauliflorous habit of cacao, if a main trunk is required on a budded tree it must be obtained from a chupon bud set low on the stock. The alternative method of budding high with a fan bud and allowing the stock to form the trunk is impracticable, because the stock would then bear fruit, and the crop would be only partly derived from the scion variety. Consequently, the choice of bud seems to be essentially a choice between presence or absence of a main trunk, and this would appear to depend more upon the tastes of the planter and the kind of cultivation he intends to give the trees than upon fundamental botanical considerations. Sub-types IA and IB are already both grown on a small scale with success, and whilst there is undoubtedly scope for experiments to compare the two, the problem seems both less urgent and less difficult than either of the two foregoing.

The Transmission Question.

In conclusion, reference must be made to a problem omitted from the main discussion in order to clarify the issues, but inseparable from any study of vegetative propagation in cacao. Harland (13) concluded, in 1924, from records of yield of budded trees kept by the Trinidad Department of Agriculture, that 'the yield of a tree affords no criterion whatever of the sort of budded offspring it will produce and the value of a tree for budding purposes must be assessed in terms of the mean yield of its budded offspring'. In 1928, from analysis of fuller data, he upheld his conclusion, and said: 'A heavy bearing tree may transmit heavy yield to its budded offspring. On the other hand it may absolutely fail to transmit and may give rise to trees which are much worse than the average. There is no method of telling whether a tree will transmit heavy yield either to its budded or seedling offspring except by testing it' (14).

A similar state of affairs is well recognized in the commercial budding of rubber, and its causes are imperfectly understood. Many possible causes suggest themselves, some of which concern compatibilities between stocks and scions, but discussion of them here would be out of place. It is evidently of prime importance to determine whether similar irregularity of transmission occurs when propagation is done by cuttings or layers, and the determination may profoundly affect not only the choice of technique to be employed, but even the whole future of vegetatively propagated cacao.

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STUDIES ON SUGAR-CANE AND SUGAR-CANE SOILS IN THE WEST INDIES.

[*Under the title of "Some Agricultural Gleanings" the "International Sugar Journal" (Vol. XXXVII, No. 434, pp. 44-48), recently reviewed three papers by Mr. P. E. Turner describing his investigations on certain aspects of the Sugar-cane Industry in the West Indies. The first section of this review deals with a paper entitled "A Critical Review of Agricultural Practices on Sugar Estates in Antigua"* (1) *and the other section discusses two papers* (2), (3) *recently published in the "Empire Journal of Experimental Agriculture". As the review should be of considerable interest to our readers the opportunity is taken to reproduce the sections dealing with the papers concerned. The papers were written in* 1933.—ED.]

I.—Agricultural Practices on Sugar-Cane Estates in Antigua. (1)

In this all stages in the cultivation of cane are reviewed.

PREPARATION OF THE LAND FOR PLANTING.

This is at present accomplished by one or other of three methods; the Fowler "gyrotiller", the tractor, and the older method of cattle ploughing which is still the dominant method in operation.

The "gyrotiller" appears to be well suited to the conditions and the need for deep and thorough cultivation on the heavy soils of the island. Especially is this the case with the alkaline and saline soils, for it brings a minimum of subsoil to the surface. But its use raises various problems. The usual practice is to plough across the beds thus filling in the drains which have to be cleared. In this clearance the soil is frequently thrown up on the sides leaving the bed hollow. The stagnant water which collects on the heavy soils is most injurious and is probably partly responsible for the large percentage of "supplies" and it offers conditions favourable for root diseases. These are effects which extend to ratoon crops, and probably limit the number of crops which can be taken. The suggested process is to plough along instead of across the beds and to attach a grader in place of a ridger. The beds will thus be given a camber but the ridges will have to be made by hand subsequently; an added cost but one which is likely to be more than offset by increased yield and reduced cost of opening the drains.

Tractor ploughing appears to be advisable for the appreciable areas of fertile alluvial soils at present ploughed by cattle. The latter can only be effected in the wet season and results in poor tilth. This change, accompanied by improvement in drainage offers promise for these areas.

Cattle ploughing is customarily performed across the bed, two cuts being made through each line of stools, and the stools and the pen manure, placed over these cuts, covered by two further cuts on each side of the old line. The unworked soil between is then ploughed or hand forked and the furrow cleaned out by the plough. Any delay in the first operation often leaves the old stools rooted. Young plant canes are found with their roots in the soil in the furrows and not penetrating the soil beneath the bank. One remedy is to make the two first cuts early, thus giving the stools time to dry out, and to follow this by two further cuts along the line of canes which will penetrate the soil to six inches below the banks. But it seems preferable on heavy soils to close-plough along the beds throwing the earth towards the centre, bank by hand subsequently and fork the soil between the rows after the banks are broken.

Cross-barring by means of earthen banks across the furrows is widely practised and has advantages in that manure can be applied under the cultivated soil of the cross-bar. But it has disadvantages on heavy soils; the soil to form the bar is scraped from the hole and the sett frequently placed in unworked soil; the hole, too, forms a natural receptacle for holding water.

Planting.

Planting takes place between November and February. It is pointed out that it may be found advisable to plant up the heavy soils before the light ones and to commence planting earlier than November.

A general tendency to closer planting is noted. It is a complicated problem involving both natural factors, the optimum distance in a wet year being different from the optimum for a dry year, and economic factors, the nature of the implements used for interculture.

The normal distance between banks is 4½ ft. increased to 5 ft. with the "gyrotiller". As the proposed method of cultivation involves working along the bed, it is proposed to line the setts along the bed with a distance of 4½ ft. between plants in the row with two setts to each hole situated at the side of the bank in the furrow and rather less than 2¼ ft. apart.

Cultural Methods.

The general custom of leaving the banks unbroken on heavy soils or even returning the soil washed into the furrow is discussed. Breaking the banks might give all the advantages, without the disadvantages of cross-bars. In the process of breaking, too, an adequate camber can readily be secured.

Pen manure is not an adequate conserver of moisture when used according to the manurial requirement and the use of trash is advocated. Trash, too, will help as a control of weeds if used to a depth of 3 in. At present weeding is a costly operation since plant canes may have to be weeded regularly up to 40 weeks. Even without trash, greater attention requires to be given to weeding which should be considered from the point of view of destroying the seed bed rather than as merely removing weed growth.

Manuring.

The common dressing of pen manure is very heavy, frequently as much as 40 tons per acre. Not only does the preparation of such large quantities result in an inferior product but the evidence from elsewhere, particularly Trinidad and Barbados, indicates that dressings above 15 tons are uneconomic.

Pen manure has been tried out against sulphate of ammonia; but since, in these comparisons, a dressing of 2 cwts. sulphate costing $2.40 per cwt. was compared with 20 to 40 tons pen manure costing $2.00 per ton, the advantage in favour of pen manure was only to be expected. It is suggested that it may be found advantageous on certain soil types to supply sulphate of ammonia some six to eight weeks after planting in the furrows in addition to the pen manure, also a further dressing at the commencement of the rainy season. The danger of getting a too forward plant which will suffer from the dry weather is not overlooked. The possibility of using filter-press mud, with potash, and sheep manure is also suggested. For the remaining lands, of which there are appreciable areas, on which it is inconvenient to apply organic manures, suggestions are made for dressings of inorganics.

Soil Amelioration.

The probable advantage of ground limestone and of green dressings on the non-calcareous clay-tuff soils and of sulphur in combination with pen manure on the less fertile, highly alkaline soils is discussed.

Varieties.

Comment is made on the fact that it is not common to find a pure stand of one variety in any field in the island, the main causes for which are selection of planting material and the use of early varieties for late supplies. Attention has already been drawn to the connexion between the need for extensive supplies and inadequate drainage. Comparison between different varieties under the varying conditions is an essential investigation.

The Review concludes with a detail of the experimental programme which has been drawn up with a view to checking the value of the many suggestions contained in the above critique. It is a comprehensive programme and the experiments are laid out in randomized plots so that the results may be subjected to statistical analysis. It says much for the enterprise of the planting community that, under the spell of severe depression, it has offered co-operation to put the programme into practice. The earliest plots were laid down late in the planting season 1933-34 owing to the late visit of the Advisory Officer.

II.—Investigations in Trinidad (Part I). (2)

This paper deals with the immediate and residual effects of lime on the crop yield, and reviews some of the results of six years' experimental work. In all cases the dressing of lime was applied immediately before replanting and none was applied to the ratoons.

General Effect of Lime on Yield.

On *unflocculated, acid soils* three experiments are recorded from heavy clay soils with a pH value from 5.6 to 6.2 and two from light loam soils with a pH value of 5.4 to 6.7. In all cases here and throughout, the lime dressing was equal in amount to the lime requirement. In all cases increments were obtained of a magnitude which might be due to chance in less than once in 100 times, whether the plant or ratoon crop be considered. The increments averaged 38.0 per cent. in the case of plant cane and 47.4 per cent. in the case of ratoons. From the detailed results it is concluded that the absolute increment in yield of plant canes, due to liming to lime requirement, is not greatly influenced by the nature of the basal manurial treatment except in special circumstances; the increment in the case of ratoons is more so dependent than in the case of plant canes. The unlimed plots have given a very poor spring in the second ratoons and it appears probable that the residual effect of liming will be sufficient to be a determining

factor in the number of crops which can be taken. Ground limestone appears to be superior to slaked lime probably owing to the difficulty in preventing the latter clotting under the local conditions.

On *exhausted soils* the response is slower. In an experiment on land previously in the hands of peasant cultivators the increases were respectively 1.68, 4.55 and 5.49 tons (equivalent to 4.9, 12.7 and 39.0 per cent.) for plant, first and second ratoon crops.

Effect of Lime in the Presence of Sulphate of Ammonia.

Two somewhat intricately designed experiments covering three crop periods are detailed; the first with B 156 on exhausted soil as described above, the second with BH 10/12 on a raw clay with a pH value 6.0. Basal dressings of ½, 1 and 1½ times the lime requirement were given in each case. The ratoons of the first received a dressing of sulphate of ammonia. The results are interesting. Curves for the crops without sulphate of ammonia follow the laws of diminishing return; those of the crops with sulphate of ammonia rise to a maximum and then fall. From the equations for the curves it is proved that the rise and fall is definitely significant and it is noted that here, for the first time, over-liming is shown to be the cause of significant falls in yield. It has been possible to work out the optimum dressing which is for the first ratoon, 0.98 and for the second ratoons 1.04 times the lime requirement. The same effect has been found in further experiments not only with the addition of lime but on the unlimed calcareous soils. Where the soil is deficient in lime the effect is not found. A previously unsuspected interaction between lime and nitrogen of this nature is here disclosed.

The work has, further, shown that a depression of yield of this type occurred generally when the manurial treatment was unbalanced and may be remedied by supplying the deficient element. Under the conditions of the experiment with B 156, 2 cwt. potash with 1 cwt. superphosphate were severally added to the basal dressing of 3 cwt. sulphate of ammonia. Here a significant fall in yield occurs only in the case of nitrogen alone at 1½ times the lime requirement, from which it would appear that the interaction takes place in the absence of adequate potash.

In explanation of the term "lime requirement" it is noted that the naturally calcareous soils on which the heaviest yields of cane are obtained, have been found to average 80 per cent. saturation with exchangeable calcium and the term as here used implies the amount of lime required to raise the lime status to the 80 per cent. level.

III.—Investigations in Trinidad (Part II) (3).

This paper deals with the immediate and residual effects of organic manures on crop yield and with pen manure in comparison with inorganic manures.

Preparation of Pen Manure.

Pen manure is not a standardized product, being made from trash, coarse grass from waste areas and, recently, a certain proportion of bagasse. Filter-press mud, distillery sludge and molasses may also be used. Quality will also vary with the length of time in preparation, about 8 to 9 months, but largely dependent on the demand. Amounts per head of cattle vary between 8 and 50 tons and the head of stock is normally determined by the demand for manure. Examples given show nitrogen ranging from 0.47 to 0.18, K_2O from 0.98 to 0.32 and P_2O_5 from 0.30 to 0.16 per cent.

Effect of Pen Manure on Yield.

In the experiments 10 tons is taken as the unit dressing and applications are made of one, two and three units. It is within the capacity of most plantations to make sufficient to give one unit to all plant canes, two units is the normal application in practice and three units is the maximum in actual use.

Effect of increasing dose on yield of a complete crop series of hardy canes.—Such canes are of the Uba type and have been found to respond to generous applications more greatly than noble canes. In all cases up to third ratoons, the increment follows a curve of diminishing return but the maximum yield is not reached with 30 tons, a result which may be compared with that of Saint in Barbados who obtained no increment above 10 to 15 tons. The four increments are in the ratio of 4 : 3 : 2 : 1 and the evidence indicates that the residual gain ceases to be measurable subsequently.

Optimum dressing.—This involves a question of costs. Allowing for cost of manufacture, transport, application and of additional reaping the net gain is found to be a maximum at 15 tons.

Effect of standard dressing on yield of a complete crop series of noble canes.—The experiments indicate that the immediate gain with plant canes approximately equals the total subsequent residual gains. Three experiments are here covered and a comparison of these indicates that a basal dressing of a complete inorganic manure reduces the immediate gain in yield and that the largest gain occurs on an exhausted soil deficient in potash. General experience, in fact, suggests that response to pen manure is greatest when potash is deficient.

Pen Manure *versus* Inorganic Manures.

Increasing doses of pen manure versus *an inorganic manure.*—To the incremental pen manure experiment above with Uba, an additional plot with a basal dressing of sulphate of ammonia (N 90 lb.), ground rock phosphate (P_2O_5, 375 lb.) and sulphate of potash (K_2O, 60 lb.) was included. The essential facts are that the yield from inorganics was significantly greater for plant canes than from 10 tons pen manure and equal to that

from 30 tons; that the first ratoon residual effect was equal to that from 30 tons pen manure and that the total yield was equal to that from 20 tons pen manure. More recent work indicates that the basal inorganic dressing was far from ideal, having an excess of phosphate which can depress yield, and with the nitrogenous component applied too late. Yet the financial gain exceeded that obtained from the optimum dressing of pen manure ($24.70 against $14.07 for 20 tons pen manure).

Rate of diminution of increment in yield on the organic and inorganic plots.—By use of a regression formula it is shown that the increment from pen manure gains on that from inorganics at the rate of 1.305 tons per annum, a gain which is significant.

Value of nitrogen in pen manure.—Twenty tons pen manure contains over twice as much nitrogen and over five times as much potash as the inorganic manure. Since the area contained ample phosphate and potash, it is concluded that, as far as immediately available nitrogen is concerned, the 300 lb. N in 30 tons pen manure is equivalent to the 90 lb. in the inorganic manure, an efficiency of 0.3 approx. For the whole crop series this figure becomes 0.45.

Pen manure in relation to soil moisture.—A number of experiments and observations are quoted which tend to show as incorrect the common belief that pen manure materially increases the capacity of soils to retain moisture in dry weather.

PEN MANURE PLUS INORGANIC MANURES.

It is probable that stock will always be required on plantations in future and that pen manure will be available and most economically produced when the head is determined by other uses than the production of manure. There is, thus, a profitable field of enquiry as to the best method of supplementing relatively small applications of pen manure with artificials. This aspect has been considered.

An interaction of pen manure with sulphate of ammonia.—In two experiments, respectively on calcareous marl and acidic raw clay, 3 cwts. sulphate of ammonia gave an increment with plant canes over double that from pen manure, but, when 2 cwt. sulphate was applied with the pen manure no further increment was obtained. In a further series on calcareous marl, sulphate of ammonia alone gave a relatively small increment over pen manure but a significant increase when applied with pen manure. The difference here exposed discloses the need for further knowledge for practical use of the results.

Pen manure and inorganic potash.—In three experiments on soils with exchangeable potash varying from 0.021 to 0.028, dressings of 2 cwt. sulphate of potash on a basal dressing of 14 tons pen manure and 4 cwt. sulphate of ammonia gave an average increment of 4.41 tons cane (on 35.6 tons), the smallest increment being on the area with the highest potash content. This is in agreement with the general experience that a response is obtained when potash is as low as 0.02 per cent.

Interaction of pen manure with lime.—On calcareous soils pen manure decomposes rapidly to a sweet smelling humus; on unflocculated lime-deficient soils to an evil smelling product. An experiment on the latter soil with lime applications of ½, 1 and 1½ the lime requirement with 20 tons pen manure showed a significant increment from the application of lime but an increment which diminished with the amount of lime. The reaction responsible appears to involve the exchangeable potash, lime rendering increasing amounts of potash available. This explanation is supported by the result of an independent experiment on soil with 0.005 per cent. exchangeable potash.

Pen manure plus sulphate of ammonia versus *a complete inorganic manure.*—Pursuing the general idea disclosed, 12 field trials, covering 100 acres were undertaken and the plant cane results given. The complete inorganic was composed of 6 cwt. sulphate of ammonia, 2 cwt. sulphate of potash and 1 cwt. superphosphate; the pen manure 20 tons supplemented with 4 cwt. sulphate of ammonia. On the average the complete inorganics gave a slightly larger yield of cane with like juice quality but the cost per ton of cane from inorganics was only four-fifths of that from pen manure and sulphate of ammonia. The soils included heavy clays.

PEN MANURE *versus* OTHER ORGANIC MANURES.

When 20 tons pen manure was compared with 2 tons sheep manure, the yield from the latter was larger but not significantly so. When 25 tons pen manure was compared with 600 lb. fish manure the corresponding two crop increments were 10.7 and 4.4 tons cane respectively.

References.

(1) Sugar-Cane Investigation Committee of Antigua; Govt. Printing Office, Trinidad, 1934.

(2) Turner, P. E.—Studies on Sugar-Cane and Sugar-Cane Soils, Part I. The immediate and residual effects of lime on crop yield. *Empire Journal of Experimental Agriculture*, Vol. II, No. 5, pp. 78-92.

(3) Turner, P. E.—Studies on Sugar-Cane and Sugar-Cane Soils, Part II. The immediate and residual effects of organic manures on crop yield: "Pen" manure in comparison with inorganic manures. *Journal of Experimental Agriculture*, Vol. II, No. 6, pp. 103–118.

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CHEMICAL NOTES.

Compiled by the College Department of Chemistry and Soil Science.

The Semichon Process of Fermentation.

The so-called Semichon process of fermentation was advanced by Professor L. Semichon, of France, in 1923 (L. Semichon, "Preparation of Wine by Continuous Fermentation" *Chem. Abstracts*, 17, 2628; original in French, *Comptes Rend. de l' Académie des Sciences*, 176, 1017-1019, 1923). Its main purpose is to control fermentation organisms and obtain a maximum yield of alcohol from the sugars in grape must without the need for SO_2 or control by pasteurization.

The grapes as they come to the winery contain many kinds of organisms capable of attacking grape sugars. Many of these are wild yeasts and moulds that decompose the sugars, but do not produce much alcohol. Among these wild yeasts there is one known as "apiculatus". The apiculate yeasts are especially abundant on the grapes, and greatly outnumber the true wine yeast, *Saccharomyes ellipsoidius*. Not only are the apiculate yeasts more numerous, but they develop very rapidly in the must. Since apiculatus and other wild yeasts are not desirable, Semichon conceived the idea of using alcohol as an agent to check their growth.

Most wild yeasts cease their growth and activity in liquid containing more than about 5 per cent. of ethyl alcohol. On the other hand, true wine yeast will withstand about 16 per cent. under normal conditions. One method of conducting the Semichon process is as follows: enough sound wine is added to fresh grape must to give 5-6 per cent. alcohol. This is allowed to ferment with selected yeast to about 1-2 Balling. This process will take about five days, according to the experiments made in the Fruit Products Laboratory, University of California. The fermenting juice is now diluted again with fresh juice to about 5-6 per cent. alcohol. The fermenting vat by this time has become heavily seeded with true wine yeast, and in two days the fermenting juice can again be diluted with fresh must. At any time fermenting juice can be drawn into other tanks or vats and fermented out completely. Semichon recommends the use of this process for controlling the temperature of the fermenting vat. Whenever the temperature of the fermenting juices approaches 90°F., fresh cold grape must may be added and thereby cool the fermenting juice. This type of cooling will aid in producing wines of higher quality without outside refrigeration. In the preferred method, however, he recommends continuous addition of must and continuous withdrawal of the fermenting must at an equal rate to complete its fermentation in other vats or tanks.

While the apiculatus and other yeasts are held in check by the Semichon process, there are other organisms that are not checked by it. Tourne and vinegar bacteria are still able to develop. In one experiment in this laboratory, using the Semichon discontinuous process, a wine was obtained that was highly infected with tourne bacteria and spoiled. It is easy to see that if the fermenting vat ever became infected with an organism such as tourne, it would be a source of infection for all the wines in the plant.

We do not recommend the method unmodified, but feel that if 75 to 100 p.p.m. of SO_2 ($1\frac{1}{4}$ to $1\frac{1}{2}$ pounds of metabisulphite per 1,000 gallons) were used to prevent growth of tourne bacteria, the method might prove useful in wineries not equipped to cool during fermentation. However, without additions of SO_2 or metabisulphite to the must, we fear that the danger from tourne would outweigh any probable advantages of the method.

The general principle upon which the process is based could be used to control temperature; thus, if fermentation in a given vat becomes too rapid and the temperature is rising dangerously high, new wine from a previous vat that is nearly completely fermented and has cooled might be added to "slow up" the fermentation rate and to cool the hot must. In other words, by judicious mixing of wine with must, or must with wine, the temperature could be held within safe limits without the use of special cooling equipment.—[*Fruit Products Jr.* Feb. 1935, p. 169. (Abstracted in *Food*, April 1935, p. 298).]

* * *

Seasonal Variations of Carbohydrates in Fruit Trees.

The second of a series of papers on "The Seasonal Cycles of Nitrogenous and Carbohydrate Materials in Fruit Trees" by members of the staff of Long Ashton Research Station (*J. Pomol. and Hort. Sci.*, Vol. XII. No. 4. pp. 249-292, Dec., 1934), deals with the seasonal cycles of alcohol-soluble materials, of carbohydrate fractions and lignin in the wood, bark and leaves of ternimal shoots of apple trees. Two cultural systems are involved, namely, trees grown on grassland, with annual dressings of nitrate in spring, and trees grown on arable land, without nitrogenous fertiliser. It is the work of Dr. Elsie S. Smyth. Well-defined seasonal variations in the amounts of all the carbohydrate fractions were found, and changes in the wood and bark were similar. Difference in cultural treatment did not greatly affect the seasonal changes, though reducing sugars were rather more abundant in material from the arable plot in summer, than in trees grown on grass. There were also differences in starch content. Carbohydrate-nitrogen ratios were, however, higher in the trees grown on grassland, than in the arable crop. Variations in the contents of alcohol-solution matter, in reducing sugars, sucrose, starch, hemicellulose, total carbohydrates, cellulose and crude lignin, are all set out in detail. —(*Nature*, Vol. 135. No. 3405, p. 191, 1935.)

SUGAR NOTES.

Compiled by the College Department of Sugar Technology.

New Method of determining Water, using Di-Electric Constant "(Exluan Process"). —*G. Steinhoff.*

Owing to the long time usually demanded in methods of drying in determining the water content of products, some of which alter under the influence of the heat applied, many attempts have been made to find a method which will prove at least as accurate and much more expeditious. Much has been expected from determinations of the di-electric constant. By this expression one understands the ratio to one another of two capacities of a condenser, the first when filled with air, and the second when filled with the product under examination.

But for several reasons the results have not always come up to expectations with many products. One reason is that in the case of loose materials the results are found to vary according to the tightness of the packing of the substance in the condenser cell. Thus, starch or raw sugar lightly packed gives a different value from that which has been well shaken down in the cell. There are several other sources of error which are difficult to control.

What appears to be a decided advance in the di-electric method is found in the "Exluan" process, which has been patented by a German firm for use with their apparatus called the "Dielkometer". "Exluan" is the trade name for certain liquids possessing a very low di-electric constant (around 2) capable, however, of freely taking up water. An example is pure dioxan having a di-electric constant of 2.2, which value is raised 12 per cent. by each 1.0 per cent. of water with which it is mixed. This provides the basis of an accurate and an expeditious method of determining water in a variety of grades of commercial products.

In operation, having set the fine scale of the "Dielkometer" apparatus on its end-point, and having read the value for dry dioxan on its larger scale, the instrument is calibrated in water percentages by running known volumes of water from a micro-burette into 50 c.c. of dioxan, and taking the several readings on the fine scale. Then the substance under examination, *e.g.*, sugars, syrups, starch, &c., is mixed with 50 c.c. of dioxan, if necessary with heating or boiling, and after cooling, the reading is taken on the fine scale to give the percentage of water. Not more than 10 to 15 min. is generally required for the determination, the precision of which is claimed to be sufficiently accurate for most commercial purposes. So far the method does not appear to have been examined particularly for sugar factory products, but some results obtained with starch, dextrin and starch syrup are shown below, where figures for the water per cent. are shown for the di-electric method which is claimed to be at least as accurate as those found by desiccation.

	Di-electric process.	Desiccation method.
Starch, sample I ..	18.9	18.7
do. II ..	17.6	17.3
do. III ..	18.9	18.5
Dextrose, sample I ..	9.8	9.5
Do. II ..	0.9	11.2
Starch syrup	23.2	22.9

—(*Inter. Sugar Jouranl*, Vol. XXXVII, No. 439, pp. 270-71, 1935.)

* * *

Decantation of Juice of P.O.J. 2878.—*G. de Carli.*

Central Leao observes that the limed juice of P.O.J. 2878 is much more difficult to decant on account of a slow rate of settling in the Dorr decanters, of which this factory has three. This forces a reduction of more that 20 per cent. in the grinding rate. Thus the question arises whether to abandon the new, more productive and more disease-resisting variety or to enlarge the settling facilities. The author considers that it would be an economic error to return to the old varieties, hence the second alternative is to be preferred.

[Three counter measures are: to grind only thoroughly ripe cane; to mix P.O.J. 2878 juice with a certain proportion of juice of other canes (this has been found quite effective), and to use the sulphitation process*. — Ed.] — (*Inter. Sugar Journal*, Vol. XXXVII, No. 439, p. 274, 1935).

* * *

Turbidity in Sugar Products. † *F. W. Zerban, L. Sattler and I. Lorge.*

The formulae developed in the previous paper, for calculating the concentration of colouring matter and turbidity in a certain raw sugar from the transmittancy and Tyndall beam intensity of its solution, have been applied to 62 other raw sugars. It has been found that the results obtained by this method check with those of Balch's method only in those cases where the properties of the particles causing the turbidity are the same as in the standard sugar. Conversely, the discrepancy between the results of the two methods serves to characterize the particle properties. It is of course fully realized that neither the colour nor the turbidity problem in sugar products can be completely solved without further fundamental knowledge of the chemical and physical properties of the constituent dispersoids present as turbidity or colouring matter, and the procedure outlined in this paper is presented merely as a step in that direction.—(*Int. Sugar Jr.*, Vol. XXXVII, No. 439, p. 272, 1935.)

* *I.S.J.*, 1935, p. 158. † *I. S. J.*, 1934, pp. 31,

TREND OF THE MARKETS.

[*The notes below are based principally upon running charts of the prices of the basic grades and upon general statistical information gleaned from contemporary publications and cablegrams and are intended to be a record of movements. An attempt is made, where possible, to indicate the market outlook at the time of going to press, but no responsibility for the accuracy and subsequent truth of such observations is assumed. Unless otherwise stated the prices quoted are spot, London.*]

SUGAR.—Prices on the Home Markets have ranged as follows (c.i.f. per cwt.).

	Foreign.		*Preferential.*	
	s.	*d.*	*s.*	*d.*
4th July	4	6¾	8	3¾
11th July	4	3¾	8	0¾
18th July	4	1¼	7	11¼
25th July	4	2¼	7	11¼
1st August ..	4	5¼	8	2¼
8th August ..	4	5¼	8	9¾
15th August ..	4	4½	8	1½
(16*th August*, 1934) ..	4	9	8	6

The market during July has been disappointing and raw values receded at one time by as much as 4½*d.* per cwt. Towards the end of the month, however, a steadier tone prevailed and quotations recovered from 2¼*d.* to 3*d.* per cwt. from the lowest point as a result of an improvement in activity in White Sugars. The article remains surrounded by uncertainties and the market, in a mood of perplexity, has adopted a waiting attitude for developments to take place. There is in particular the constant uncertainty as to what the Cuban crop and marketing programme to countries outside the U.S.A. is to be.

* * *

RUBBER.—Quotations for Plantation Sheet have ranged as follows :—

	Pence per lb.
3rd July	5 15-16
10th July	5 15-16
17th July	5 7-8
24th July	5 5-8
31st July	5 13-16
7th August	5 7-8
14th August	5 11-16
(15*th August*, 1934)	7 1-2

The market has generally been dull and prices have sagged slightly. Among factors which have had a depressing influence may be included disappointing returns of consumption in the United States, excess shipments of native rubber from the Dutch East Indies, and falling markets in other commodities especially wheat. Holland's financial difficulties have also caused some nervousness.

* * *

LIME PRODUCTS.—*Lime Oil.* First hand supplies of Handpressed are available, the normal value remains at 37*s.* 6*d.* to 40*s.* per lb. There is a better demand for Distilled, and sellers are firm at 22*s.* 6*d.* per lb. ex wharf. *Lime Juice.* There has been no improvement in the demand for Concentrated. Raw shows no change since our last report.—(*West India Committee Circular*, 18th July, 1935.)

COCOA.—Sales of new West African crop will be as long delayed as possible due to large stocks of old crop still unsold, but as this crop ordinarily commences to move in a small way in September, and is normally in fairly full swing by October, it is evident that offerings must soon make their appearance. The spot position in New York, however, has in it the possibilities of bringing about a better market. West African shippers will delay selling in the hope of higher prices developing within the next month or six weeks. Old crop Accra is quoted at 22*s.* c.i.f. and new crop could possibly be obtained at 22*s.* 3*d.* Locally $5.50 a fanega is generally paid for plantation cocoa.—(*By courtesy of the Cocoa Planters' Association of Trinidad, Limited.*

* * *

COTTON.—The following are the official spot prices in pence per lb. of the Liverpool Cotton Association :

	American Mid.	*Egyptian F.G.F. Sakel.*
5th July	6.94	8.04
12th July	6.94	7.99
19th July	7.02	8.03
26th July	6.80	8.07
2nd August	6.68	—
9th August	6.69	—
16th August	6.47	—
(17*th August*, 1934) ..	7.11	8.61

Quiet conditions have generally prevailed in the American raw cotton market and prices as a result have only fluctuated within narrow limits. The acreage estimate for the American crop was about equal to expectations. Weather conditions have also improved and the crop is looking much better. The area under Egyptian cotton is estimated at a slightly lower figure than last year. West Indian Sea Island has realised from 15*d.* to 17*d.* per lb.

* * *

BANANAS.—The demand for both Jamaicas and Brazilians has continued good. Prices have been advanced by £1 and 10*s.* per ton to £18 5*s.* per ton delivered and £18 to nearest station for Jamaicas and to £17 10*s.* nearest station for Brazilians.

The imports into the United Kingdom for the fortnight ended 29th June amounted to 1,023,942 bunches consigned by the following countries :—Jamaica, 888,085 ; Gold Coast, 697 ; Canary Islands, 12,562 ; Brazil, 77,028 ; Colombia, 45,570. — (*West India Commitete Circular*, 18th July, 1935.)

* * *

COPRA is a quiet market with values of West Indian f.m.s. slightly lower at £11 for spot and £11 5*s.* c.i.f. for forward shipment.—(*West India Committee Circular*, 18th July, 1935.)